



April 30, 2014

Congressional Committees

Missile Defense: DOD's Report Provides Limited Insight on Testing Options for the Ground-based Midcourse Defense System

The Missile Defense Agency (MDA) has sought to rapidly develop and field the Ground-based Midcourse Defense (GMD) system to defend the United States against a limited intermediate and intercontinental ballistic missile attack from nations such as North Korea and Iran. The GMD system defends against these threats by launching a ground-based interceptor toward the enemy ballistic missile, releasing a kill vehicle that detects and destroys the threat. In March 2013, we found the total cost of the GMD system to be around \$41 billion, approximately \$4.5 billion of which will be spent between fiscal years 2013 and 2017.¹ Currently, the Department of Defense (DOD) has deployed 30 GMD interceptors and it plans to deploy 14 more by the end of fiscal year 2017. However, flight testing intended to demonstrate the system's capabilities and limitations is not scheduled to be completed until at least 2022. Since 2003, we have found this approach of concurrently manufacturing, deploying, and testing interceptors is high risk because tests may uncover issues requiring costly design changes and retrofit programs.² These risks materialized when MDA failed both of its attempts in 2010 to demonstrate the upgraded GMD interceptor, called Capability Enhancement (CE)-II, causing MDA to fall several years behind on deploying new interceptors. Additionally, the cost to demonstrate, as well as fix, the already produced CE-IIs has increased from \$236 million to \$1.309 billion.³

A second CE-II attempt to intercept a target missile, called Flight Test GMD (FTG)-06a, occurred in December 2010. According to the Director, MDA, the test failed because of excessive vibration in the inertial measurement unit—a component of the kill vehicle's guidance system. As a result, MDA halted deliveries of the remaining CE-IIs until the failure is resolved. We reported in April 2012 that the failure investigation for FTG-06a concluded the inertial measurement unit required a redesign and additional development.⁴ MDA developed and

¹See GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, [GAO-13-294SP](#) (Washington, D.C.: Mar. 28, 2013), 51.

²See GAO, *Missile Defense: Knowledge-Based Practices Are Being Adopted, but Risks Remain*, [GAO-03-441](#) (Washington, D.C.: Apr. 30, 2003); and more recently, *Missile Defense: Mixed Progress in Achieving Acquisition Goals and Improving Accountability*, [GAO-14-351](#) (Washington, D.C.: Apr. 1, 2014).

³In April 2013, we found that MDA initially planned to demonstrate the CE-II capability for an estimated \$236.3 million but subsequently increased to \$1.1739 billion as of August 2012 (see GAO, *Missile Defense: Opportunity to Refocus on Strengthening Acquisition Management*, GAO-13-432 [Washington, D.C.: Apr. 26, 2013], 90). Since then, we received updated cost information from MDA in June 2013 and the total cost is now estimated at \$1.3091 billion. This recent cost increase was largely a result of a \$146.5 million cost increase of the test failure review.

⁴GAO, *Missile Defense: Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency*, [GAO-12-486](#) (Washington, D.C.: Apr. 20, 2012).

Report Documentation Page			Form Approved OMB No. 0704-0188	
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1. REPORT DATE 30 APR 2014	2. REPORT TYPE	3. DATES COVERED 00-00-2014 to 00-00-2014		
4. TITLE AND SUBTITLE Missile Defense: DOD's Report Provides Limited Insight on Testing Options for the Ground-based Midcourse Defense System			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER	
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Government Accountability Office, 441 G Street NW, Washington, DC, 20548			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)	
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited				
13. SUPPLEMENTARY NOTES				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF: a. REPORT b. ABSTRACT c. THIS PAGE unclassified unclassified unclassified			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 24
				19a. NAME OF RESPONSIBLE PERSON

implemented steps to mitigate the effects on that guidance component and successfully tested the mitigation in a non-intercept flight test, called Controlled Test Vehicle-01, in January 2013. MDA plans to further demonstrate the mitigation through an intercept flight test called FTG-06b, which, if successful, will allow interceptor deliveries to resume. The program experienced a setback, though, in July 2013, when the program failed an intercept attempt of the initial fielded version of the GMD interceptor, called CE-I, which has subsequently delayed FTG-06b to the third quarter of fiscal year 2014.⁵

The National Defense Authorization Act for Fiscal Year 2013 provided that: MDA's highest priority should be to correct the problem that caused the FTG-06a test failure; MDA should demonstrate the correction in flight tests before resuming CE-II production; and MDA should have a robust, rigorous, and operationally realistic GMD testing program.⁶ Additionally, the act required the Secretary of Defense to submit to congressional defense committees a report on GMD's test program that included, among other items: an explanation of GMD test options if Controlled Test Vehicle-01 and FTG-06b do not demonstrate the successful correction to the problem that caused the FTG-06a failure; and an assessment of the feasibility, advisability, and cost effectiveness of accelerating GMD's flight testing pace.⁷

In addition, the act required GAO to brief the congressional defense committees on our views of DOD's report and submit a report as soon as practicable. For the briefing, we assessed: (1) the extent to which DOD's report identified testing options and known risks of the GMD system, and (2) the extent to which DOD's report assessed the feasibility and cost effectiveness of accelerating GMD flight testing. This report formally transmits the briefing that we provided to the congressional defense committees on December 16, 2013, which is attached as an enclosure, and meets the reporting requirement.

To assess the extent to which DOD's report identified testing options, we reviewed DOD's report for testing options if FTG-06b does not demonstrate the successful correction to the problem that caused the FTG-06a failure. We then compared those testing options against MDA's testing plans. To assess the extent to which DOD's report assessed the feasibility and cost effectiveness of accelerating GMD's testing plan, we compared information included in DOD's report to a generally accepted definition of the term feasible (the extent to which something is both possible and likely to occur) and assessed the support provided in DOD's report against GMD's testing performance. We also compared information contained in DOD's report to GAO, Office of Management and Budget, and DOD guidance on the elements of a cost effectiveness assessment. Due to lack of availability of data, we did not independently assess whether accelerating GMD's testing pace was advisable. Finally, we met with MDA and DOD officials to corroborate key acquisition information.

The issuance of this report was delayed by about a month because of delays in the security review process performed by DOD. DOD initially identified classified and sensitive information in our draft report but subsequently reversed its determination after we referred DOD to several publicly released documents that included the same information. We also revised some

⁵MDA initially planned to conduct FTG-06b in the third quarter of fiscal year 2012 but the test was delayed to the second quarter of fiscal year 2014 because of challenges developing the FTG-06a mitigation. The July 2013 CE-I test has further delayed FTG-06b to third quarter of fiscal year 2014 in order to implement corrective actions based on an ongoing failure review of the CE-I test.

⁶Pub. L. No. 112-239, § 228(a)(4), (6).

⁷Pub. L. No. 112-239, § 231.

language in our report, as appropriate, based on DOD's security review. As a result of these discussions and revisions, DOD confirmed that this report does not contain classified or sensitive information.

We conducted this performance audit from April 2013 to April 2014 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Summary

DOD's report provided decision makers with limited insight on potential testing options if MDA does not successfully demonstrate a correction to the problem that caused the December 2010 FTG-06a failure. First, we found that DOD's report included one testing option—a development effort to redesign and test kill vehicle divert thrusters, which help maneuver the kill vehicle in flight. According to the Director, MDA, this effort will address the systemic problem of vibration which is currently being addressed by isolating the inertial measurement unit from that environment. In our view, it was reasonable for DOD to focus testing options on plans to address the vibration problem. However, DOD's report included few details about that development effort, such as the cost, schedule, benefits, and risks, leaving decision makers with limited insight on this option. Second, we also found that DOD's testing options were limited because of a July 2013 intercept failure of the fielded CE-I interceptor. Until the ongoing CE-I failure review is completed and the root cause is determined, it would be premature in our view for MDA to determine the timing and nature of additional CE-I testing.

DOD's report provided limited insight into the feasibility and no insight into whether accelerating GMD's testing pace would be cost effective. We found that DOD's report did not provide a complete assessment as to whether it is feasible to increase GMD's testing pace. Specifically, the report did not assess whether it was likely MDA could accelerate GMD's testing pace—limiting the report's usefulness for decision makers. We also found that DOD's report included some basic cost information but did not provide decision makers with an assessment of whether increasing GMD's testing pace would be cost effective. Further, in our view, it is unlikely that DOD can successfully accelerate the pace of GMD's testing given its testing track record and the increasing complexity of planned tests. In addition, the report provided insufficient information to assess whether accelerating GMD's testing pace is prudent because it did not address the potential full cost, benefits, and risks of accelerating testing.

We provided a draft of this report to DOD for review and comment. Although DOD provided technical comments for our report and we incorporated them as appropriate, DOD did not provide written comments to include in this report.

We are sending copies of this report to the appropriate congressional committees and to the Secretary of Defense. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-4841 or chaplainc@gao.gov. Contact points for our Offices of Congressional Relations and Public

Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are: David Best, Assistant Director; Carol Petersen; Steven Stern; Robert Swierczek; Brian Tittle; Hai V. Tran; and Alyssa Weir.

A handwritten signature in black ink, appearing to read "Cristina Chaplain".

Cristina Chaplain, Director
Acquisition and Sourcing Management

Enclosure

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Enclosure



Enclosure

Ground-based Midcourse Defense System Test Plan

**DOD's Report to Congress Provides Limited
Insight on Testing Options for the Ground-based
Midcourse Defense (GMD) System**

*Prepared for a Briefing of the Congressional Defense
Committees on December 16, 2013.*

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Overview

- Introduction
 - Objectives
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 - Background
 - Objective 1: GMD testing options and known risks
 - Objective 2: Feasibility and cost effectiveness of accelerating GMD's testing pace
 - Concluding Observations
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-

Introduction

- The Missile Defense Agency (MDA) is developing the Ground-based Midcourse Defense (GMD) system to defend the United States against a limited intermediate and intercontinental ballistic missile attack.
- The GMD program relies on ground and flight testing to assess and demonstrate system capability, but has failed all three of its intercept tests since 2010.
- GMD's 2010 flight test failures have disrupted its broader developmental flight test plan and has resulted in cost growth of over \$1 billion due to, in part, re-conducting flight tests and conducting reviews of test failures.

National Defense Authorization Act for Fiscal Year 2013 GMD Test Report Requirements

The National Defense Authorization Act for Fiscal Year 2013 (FY13 NDAA), Pub. L. No. 112-239, Section 231, required the Secretary of Defense to submit to congressional defense committees a report on the GMD testing program and include:

Part 1	Part 2	Part 3	Part 4	Part 5
<i>An explanation of testing options for the ground-based midcourse defense system if planned flight tests CTV-01 and FTG-06b do not demonstrate the successful correction to the problem that caused the failure of the capability enhancement-2 kill vehicle in flight test FTG-06a in December 2010, including additional testing of the capability enhancement-1 kill vehicle.</i>	<i>An assessment of the feasibility, advisability, and cost effectiveness (including the potential benefits, risks, and impact on the current test plan and integrated master test plan for the ground-based midcourse defense system) of adjusting the test plan of the ground-based midcourse defense system to accomplish, at an acceptable level of risk-</i> <i>(A) accelerating to fiscal year 2014 the date for testing such system using a capability enhancement-1 kill vehicle against an intercontinental ballistic missile-range target; and</i>	<i>If the Secretary determines that either option described in subparagraph (A) or (B) of paragraph (2) [accelerating the test date for capability enhancement-1 testing and increasing the pace of flight testing] would be feasible, advisable, and cost effective, a discussion of whether increased funding beyond the funding requested in the budget for fiscal year 2013 is required to carry out such options and, if so, what level of increased funding would be necessary to carry out each such option.</i>	<i>Any additional matters the Secretary determines appropriate.</i>	<i>DOT&E [Director, Operational Test & Evaluation] Views.—The Secretary shall include an appendix to the report under subsection (a) that contains the views of the Director of Operational Test and Evaluation regarding the contents of the report.</i>

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Objectives

The Act further requires the Comptroller General to brief the congressional defense committees on his views of DOD's report.

Our specific objectives are to answer the following questions:

1. To what extent does DOD's report identify testing options and known risks of the GMD system?
2. To what extent does DOD's report assess the feasibility and cost effectiveness of accelerating GMD flight testing?

Scope and Methodology

To assess the extent to which DOD's report identified testing options, we reviewed DOD's report for testing options if Flight Test GMD (FTG)-06b does not demonstrate the successful correction to the problem that caused the FTG-06a failure. We then compared those testing options against MDA's current testing plan and baseline report. We also met with MDA and DOD officials to corroborate key acquisition information.

To assess the extent to which DOD's report assessed the feasibility and cost effectiveness of accelerating GMD's testing plan, we compared information included in DOD's report to a generally accepted definition of the term feasible (the extent to which something is both possible and likely to occur) and assessed the support provided in DOD's report against the GMD's testing performance and environment. We also compared information contained in DOD's report to GAO, Office of Management and Budget, and DOD guidance on the elements of a cost effectiveness assessment. Due to lack of availability of data, we did not independently assess whether accelerating GMD's testing pace was advisable. We also met with MDA and DOD officials to corroborate key acquisition information.

Background – GMD System Overview

Components of the GMD System		
Component	Mission	Location
Ground Based Interceptor (GBI)	The interceptor consists of a silo-based, three-stage booster stack and a "hit-to-kill" exoatmospheric kill vehicle. The kill vehicle is the weapon component of the interceptor that detects and destroys the threat through a hit-to-kill impact.	Missile fields in Ft. Greely, Alaska and Vandenberg Air Force Base, California
Fire Control and Communications	The fire control (battle management) component is the integrating and controlling entity of the GMD element. Its sophisticated software plans engagements and tasks GMD components to execute a mission. The in-flight interceptor communications system enables the fire control component to communicate with the kill vehicle while in flight.	Fire control nodes in Ft. Greely, Alaska, and Shriever Air Force Base, Colorado
<ul style="list-style-type: none">• The GMD program has completed fielding 23 of the original GBI missiles with the Capability Enhancement I (CE-I) version of the exoatmospheric kill vehicle (EKV), one of which was used in a flight test.• The GMD program has also manufactured and delivered 13 of the GBI missile with the Capability Enhancement II (CE-II) version of the EKV, three of which have been used in flight tests.• On March 15, 2013, the Secretary of Defense announced the U.S. will deploy 14 additional CE-II GBIs by fiscal year 2017, increasing the number of deployed GBIs from 30 to 44.		

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Background – GMD Testing Issues

GMD Intercept Flight Test History¹

CE-I Interceptor Tests		
Test Name	Test Date	Test Result
FTG-02	Sep 2006	Success – met primary objectives ²
FTG-03	May 2007	Failure – target failed
FTG-03a	Sep 2007	Success - intercept
FTG-05	Dec 2008	Success - intercept
FTG-07	Jul 2013	Failure – review ongoing

CE-II Interceptor Tests		
Test Name	Test Date	Test Result
FTG-06	Jan 2010	Failure – EKV failure
FTG-06a	Dec 2010	Failure – EKV failure

Source: GAO Analysis of MDA Data

1. Includes only intercept tests involving operationally configured interceptors.
2. Although an intercept was not part of the test's primary objectives, the kill vehicle hit the target. However, DOT&E has reported that the hit would not have resulted in a kill.

Background – FTG-06a Failure Cause and Resolution Status

FTG-06a

- FTG-06a failed in December 2010, according to the Director, MDA, because of excessive vibration in the inertial measurement unit (IMU).
 - IMU: guidance system sensor that provides flight data to assist EKV navigation.

Controlled Test Vehicle – 01 (CTV-01)

- CTV-01, a non-intercept flight test, was conducted in January 2013 to demonstrate the performance of the redesigned guidance system component.
 - According to DOD budget documents, MDA developed a cradled IMU in response to the FTG-06a failure.
- The Director, MDA stated CTV-01 demonstrated the successful dampening of the vibration environment that caused the FTG-06a failure.

FTG-06b

- FTG-06b is intended to resolve the FTG-06a failure by demonstrating the cradled IMU and newly developed firmware through an intercept test.
 - FTG-06b was originally scheduled for 3rd quarter of fiscal year 2012 but has since been delayed to at least the 3rd quarter of fiscal year 2014.
- According to MDA, interceptor production will restart if FTG-06b is successful.

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Objective 1

Objective 1: To what extent does DOD's report identify testing options and known risks of the GMD system?

Finding 1: DOD's report included one testing option—the development and future testing of alternate divert thrusters—but included few details, leaving decision makers with limited insight on the testing option.

Finding 2: The recent FTG-07 intercept failure, with an ongoing failure review, precluded DOD from developing CE-I testing options.

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Objective 1 – DOD Reported One Testing Option, With Few Details

What DOD Reported

- MDA is developing alternate divert thrusters expected to mitigate the vibration problem that was the root cause of the FTG-06a failure.
- MDA plans to test the alternate divert thrusters after FTG-06b.

GAO Views

- The report included few details on how or when the alternate divert thrusters would be developed and tested, such as: (1) development and testing strategy; (2) cost, schedule, benefits, and risks; and (3) impact on new production and fielded interceptors.
 - We requested more information, but did not receive any in time to assess the development and testing plans for this option.
- While DOD should pursue efforts to resolve the root cause of recurring issues revealed in flight tests, more information is needed about alternate thruster development testing plans.
- It was reasonable for DOD to focus testing options on plans that would address the vibration problem. The root cause of any FTG-06b failure would need to be known and addressed before determining additional CE-II testing options.

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Objective 1 – Latest CE-I Test Failure Precluded DOD from Providing Additional Testing Options

What DOD Reported

- FTG-07, a CE-I intercept test conducted July 2013, was unsuccessful and the failure review is currently ongoing.
- FTG-07 was primarily intended to demonstrate the effectiveness of the CE-I interceptor against an intermediate range target using updated software that improves performance.

GAO Views

- At the time the FY13 NDAA was enacted in January 2013, DOD had a variety of testing options under consideration, including CE-I tests, to address the FTG-06a failure.
- However, because DOD later added and conducted FTG-07 and it failed, that failure and MDA's ongoing failure review precluded DOD from providing CE-I testing as an option until the root cause of that failure is identified and resolved.

Jan 2, 2013 – FY13 NDAA
enacted

July 5, 2013 – FTG-07 failed

Oct 18, 2013 – DOD submitted
GMD test report

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Objective 2

Objective 2: To what extent does DOD's report assess the feasibility and cost effectiveness of accelerating GMD flight testing?

Finding 1: DOD's report did not provide a complete assessment as to whether it is feasible to increase GMD's testing pace—limiting the report's usefulness for decision makers.

Finding 2: DOD's report included some basic cost information but did not provide decision makers with an assessment of whether increasing GMD's testing pace is cost effective.

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Objective 2 – DOD Report Did Not Provide a Complete Feasibility Assessment

What DOD Reported

- With additional funding, it should be possible to accelerate GMD's testing pace to three flight tests every two years beginning in fiscal year 2018.
- The requirement to meet fielding obligations of 44 GBIs, availability of targets, and the need to increase personnel and testing infrastructure limit DOD's ability to accelerate testing before fiscal year 2018.

GAO Views

- For our assessment, we defined feasibility as the extent to which something is both possible and likely to occur.
- While DOD's report stated that it should be possible to accelerate the pace of testing, it does not address whether it is likely.
- It is not likely that testing could be accelerated given the program's track record and the increasingly complex developmental tests it will be attempting.
 - Because of a number of flight test delays, anomalies, and failures, the GMD flight test program has not been stable since 2005.
 - Each successive test explores new areas of performance, increasing in complexity and difficulty.

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Objective 2 – DOD Report Did Not Include a Cost Effectiveness Assessment

What DOD Reported

- To increase GMD's testing pace beginning in fiscal year 2018, additional funding for infrastructure, personnel, interceptors, and targets would be needed.

GAO Views

- For this assessment, we defined a cost effectiveness assessment as a comparison of the total costs with the projected benefits and risks of the action(s) under consideration.
- DOD's report did not make a determination as to whether it is cost effective to increase GMD's testing pace beginning in fiscal year 2018.
 - DOD's report included some limited cost information, but it is unclear what the total costs are and whether the costs are full and complete because they provided few details.
 - DOD did not discuss the benefits and risks of accelerating testing in the body of its report.
- DOT&E identified risks in their appendix of DOD's report that GMD's flight tests are becoming more complex and therefore, "Rushing to test threatens the adequacy of the analyses of previous test results" and "increases the risk MDA will miss or overlook important information that could affect subsequent tests".
- DOD did not address the advisability of adjusting their test plan in their report.

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Concluding Observations

- DOD's report provided decision makers with limited insight on potential testing options. While some of the testing option limitations were unavoidable, additional information on test plans for the alternate thruster development would be beneficial for Congress. In our view, alternate thrusters could be a means of resolving the root cause of the failure, but additional information on development and testing plans is needed.
- DOD's report provided limited insight into the feasibility, and no insight into the cost effectiveness and advisability of accelerating GMD testing. In our view, it is unlikely that DOD could successfully accelerate GMD's testing given its testing track record and the increasing complexity of planned tests. The report provided insufficient information to assess whether accelerating GMD's testing pace is prudent because the potential full cost, benefits, and risks are not provided in the report.

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Summary of Agency Comments

We obtained technical comments from DOD and incorporated them as appropriate in the briefing.

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